Quantam Mechanics

Introduction

If you have picked up this book, you most likely think of quantum mechanics as a course taught in select colleges, a concept that only a select few individuals with the mental caliber can truly understand and appreciate its complexity. I may have lied in the title, quantum mechanics when taught in prestigious universities and when studied upon heavily is not for the ordinary man with formulas and theories so complex that it makes even the brightest minds and most powerful computers stutter as they attempt to unify the many solitary principals that never seem to coexist with each other. However, that’s not to say that most of the essentials of quantum mechanics can be learned by the majority of the world’s population. If you do not believe so, just remember the person as of writing this book is less than 15 years of age.

Quantum mechanics is a concept however that you may need to put a bit of effort into. Unlike the concepts of regular physics that we can observe with our own eyes, quantum physics cannot. Combined with the vast myriad of

theories, your perspective on quantum physics can vary tremendously compared to someone elses. And lastly, quantum physics is extremely strange and illogical. If you want to know about quantum physics, read along, but if you want to truly appreciate the contents in the concept, you must unlearn and remove any superstitions of many of the most fundamental forces and rules in our universe.

This book will not make you a certified expert at quantum physics that’s for sure. But it will provide you with an insight on the fundemental concepts that will allow you to formulate your own perspective on the workings of the universe. For you Big Bang theory watchers, this book can also allow you to understand all the jokes made in the series.

If you have an understanding of the very basics, you may skip the first few chapters of this book. Yet if not, it’s completely fine to start off at the basics. Without another lengthy set of words and sentences, let us go straight to the point and explore the fundementals of quantum mechanics.

Terms and concepts to be familiar with

These will still be explained in the book but for proper reference, here is a list of the main terms and terminologies that are commonly used in quantum physics. You do not need to read this if you are completely new to the concept as it may take furturer reading in the book to understand these concepts.

Plank length: The smallest possible length of distance in which classical physics remains intact. Distances below this are effected significantly by quantum gravity and fluctuations that it’s impossible to conclude the location and velocity of a particle at the same time.

General relativity: Suggests gravity to just be the influence of mass on its warping of a field referred to as spacetime, consisting of 3 spatial dimensions and the dimension of time.

Special relativity: Suggests that mass of an object can change due to it’s speed. Thus the formula E=MC^2, where E is energy, M is mass and C is speed of light.

Wave function: Describes the quantum state and properties of the wave as do normal functions for lines in classical physics.

Tachyons: Theoretical particles that can travel faster than the speed of light and are massless particles. Such existence of these particles can lead to extreme paradoxes to occur however.

Reduced plank constant: Used heavily in calculations, the reduced plank constant assumes its distance if used in a polar coordinate like system and substitutes rotational speed by angular. The value is approximately Planks constant divided by 2π

A prolouge

Long before quantum mechanics had originated as a branch of science, on the 14th of December of 1900, besides a select few, the world believed in the world of Newtonian physics and the classical laws of light that are taught in elementrary and middle schools alike.

The 3 laws of physics seemed absolutely perfect and the formulas for gravity and the laws that determined everything that we see in our day to day lives seemed flawless as well. Yet questions started arising 100 years even before quantum mechanics was originated with the double slit light experiment.
Yet it took Max Plank in 1900 to publish a paper

on what is the subject known as blackbody radiation and one of it’s strange phenonemons that if tried to be explain dby regular physics, turned into absolute nonsense. More on the topic later but his main finding of theorizing distance to not be continuous, but rather discrete and divided into indivisible units of distance called quanta opened the gates to what is now known as quantum physics and helped in explaining other quantum pheoenemons such as Einstines photoelectric effect. Those lengths are now knows as the Plank length.

It took a slow and gradual process till the late 70’s to make quantum mechanics desired all over the world. From the photoelectric effect, which refers to the emission of electrons as electromagtneic radiation travles to quantam field theory, the old and new quantization of theories has lead to remarkable achievements in our field of understanding of science as a whole.

Chapter 1: Blackbody Radiation and the Photoelectric effect

Before diving into the world of quantum mechanics, let us see 2 instances of it’s application to help clear out the dilemmas on this topic as a whole.

Onto the study of blackbody radiation, in simple terms, a theoretical perfect blackbody should be able to absorb all the light which is known as electromagnetic energy. The object also should be able to emmit its own thermal and light signature as well.

The body is said to be theoretical as no known object is a perfect absorber of light, but the closest example as of what we know, can be stars such as our sun. Some of you may argue on black holes as being perfect contenders, and yes they are technically perfect black bodies, but the hawking radiation they emmit is different from classical bodies.

Now, when we heat up an Iron rod for instance, we can see the rod changes color from dull red, to red, then orange and so on. Physicist also noticed that when graphed, objects tend to have sudden spikes when they release the most amount of a specific frequency of light before it falling off. The general trend was when the wavelengths of these lights were lower, the energy released was higher.

This lead to what is known as the ultraviolet catastrophe. Theoretically, as we approach the

smallest possible wavelength, the energy released would be infinite or atleast incomprehensible. Not only does it not make sense, but showed in tests to have completely different real results.

It wasn’t until Max Plank, proposed of the solution that differed from the classic laws of physics and thermal laws of energy did the catastrophe have a reasonable scientific solution. He suggested the energy of such objects to have discrete instead of previously treated continuous values. The formula E=NHF was thus formulated where energy was equyal to any integer, thus the letter n, times “H” which referred to planks constant of energy at 6.626 x 10^{-34}
Joules per second into the frequency of radiation.

Later on formulas such as the Wien’s approximation expanded upon Plank’s solutions along with inspiring Niel Bohr’s model of atoms suggesting electrons can not just stake up any continuous state. However, it was planks theory that these energies and values must be quantized, or can’t just take any supposed value that opened the door to the possibilities of quantum physics.

One of these possibilities that he opened up the door to was Einstines photoelectric effect. He noticed that beams of light sometimes release electrons when it contacts particular surfaces. This he attributed to light consisting of particles, in which we now know today as photons. It also defined the Plank Einstine relation where the energy of light can be formulated as E=hf where f is the frequency of the wave itself and h is the planks constant.

Now you may be wondering how does this relate to the other pheonemons in the book. Well as I had stated in the introduction, quantum mechanics isn't a study of complex physics, but physics at the small fundamental levels, at sizes that we cannot see. So again, it's best to remove your misconceptions and expectations as you read along. However the next few chapters would be detailed of what most of you would be expecting in such a book.

Chapter 2: Schodigners Cat and superposistitions

A few of you reading this book would have probably heard of Schrodigners cat already and yes, this is the simplest concept of the whole book. But nonetheless, it's fundamental in

explaining all of the deeper and significantly more complex elements going forward.

Onto the concept, to all those who are reading this, I want all of you to formulate the instructions that I state in the paragraph in your brain. Then answer the question at the very end.

Imagine a cat that is stuck inside a box with no way out. Inside is a bomb that will explode if an element, contained within decays, which will then kill the cat. Now, within a period of one hour, this certain element has a 50% chance of decaying. Now the question is, is the cat dead or alive?

This seems extremley trivial, however the answer to this proposes a concept that is crucial for many deeper theories and appliances of quantum mechanics.
Onto the answer, the cat cannot be proven to be either dead or alive. Therefore, quantam physics decided that the cat is in both states, dead and alive until observed in which case is opening the box.

But how can the cat be dead or alive, one may ask. This is again why I asked all of you readers unfamiliar with quantum mechanics to remove

any superstitions on general laws in physics and in the real world.

The answer is that the cat is in a special state of being both dead and alive. This state is known as a superpositition. And it is in that state until we observe the box or if the material has decayed or not. So until we can conclude by observation that the material has decayed, at that period, the cat and the element are in a superposistition where the cat is alive and dead and the element has decayed and has not decayed.

Now this may sound extremely illogical, but here is an even simpler example. Imagine you flip a coin. Until you observe this coin, there is no way with certainty that one can predict if it’s heads or tails. So until observed, the coin is in a superposistition of being in both states.

Now this concept is actually used in the real world in computers. Not the computers that you use in your day to day lives, but by a special type called quantum computers.

Explained simply, regular computers store data in bits, which can have 2 states, 0 or 1. Quantum computers elevate this by having bits in superposistitions, in which until the computer

observes it, the bit can be in the form of 0 or 1.

You might think that this is absolutely useless. And if you had thought so, you are exactly right, else we would be using quantum computers since 1998. However, quantum computers are only useful for extremely high levels of mathematical calculations and computations that are just impossible even with the most advanced regular calculators.

Schrodigner as a scientist has contributed immensely towards the world of quantum mechanics. This simple though experiment has oversimplified such a complicated topic of superposistitions into something that even children can digest. Yet this explains the concept of superposistitions thoroughly and accurately enough.

Now that we have understood the fundamental principals of superposistitions and their implications in the real world, let us apply this on light and understand more about it’s true nature than what we usually observe.

Chapter 3: Wave particle duality and the double slit light experiment

Another example of superposistitions being used are in the double slit light experiment. Surprisingly, in terms of a historical context, this was performed back in 1801 by a scientist known as Thomas Young. Yet the results of this experiment allowed us to infer properties of light that have changed our direction in understanding our universe as a whole.

The experiment goes like this. If you take 2 slits parallel and of equal length at balanced positions and focus 1 beam of light through them, you would expect 2 separate beams of light on the other side, considering the room was pitch dark. However, the results were the wall had just 1 cross section of light on the other side.

Most of you would think that this was due to the light being not very focused and scattered, causing this 1 cross section. Yet when scientists tried using pulsed electron beams that only go through 1 slit, the cross section extended to the other side of the slit as well, almost identical in form to a normal beam of light. Therefore what should be happening is that the electron is going through both of the slits and when it interferes with itself after passing through the slit, it creates the cross section which as a unique wave

pattern.

However, the real insane part of this experiment is when they decided to observe an individual electron. Instead of the logical hypothesis, the electron just when through 1 of the slits, which thus caused an eventual 2 different cross sections of light on the other side.

Therefore in this experiment, until observed, the electron or photon (particle for light), goes through both slits, being in a sort of superpositiion.

Now that we covered these 2 basic concepts, we can go onto something much more entertaining in quantum physics.

Chapter 4: Hesienberg uncertainty principle

This is a fairly simple concept, named after a brilliant pioneer in quantum mechanics, Werner Heisenberg, but one that makes quantum mechanics significantly harder than it should be. This is ironically, one of the only principals in quantum mechanics we are certain about.

Anyways, into the principal, I want all of you to take a look around your surroundings. After a

while, ask yourself, how am I able to see these? Most of you would know the answer and think due to the reflection of light. This is correct and as human observers, the only way without technology to conclude the posistition, form and other properties of an object.

Now the problem arises if we try to see things on a molecular or even smaller quantum level. Keeping in mind the dual wave particle nature of light, at molecular levels and lower, light can not reflect properly off matter in this state as matter is now at such small states, that for one there is a significant amount of empty space and another being that even if it does reflect and we are extremley luckly to receive it, the photon would be depicting the state or posistition at a completely different place than where it actually is.

In short, Heisenbergs uncertainty principle does not allow us to know both the posistiion and the velocity at any given time. However, this only applies in atomic levels and gets even worse when we enter subatomic and plank length scales of the world, where the fundamental laws of physics and even many interpretations of quantum physics break down.

Chapter 5: Teleportation and virtual particles

These are firstly 2 extremnley short and closely relasted topics, thus combined into one chapter. However, these are also extremely interesting topics that if explained simply, can be understood simply.

Onto quantum tunneling, which in simple words is basically teleportation. In classical physics and in our normal world, if there is a solid brick wall, there is no way we can go through this wall by simply walking straight. However, this sort of concept does not exits in quantum mechanics.

Due to the sheer tiny scales of the particles, if for example, a particle tries to go past a barrier, usually of incomprehensible thinness, there is a good chance the particle simply appears on the other side of the barrier.

With a more detailed explanation, the wavefunction of a particle be it the schrodigners equation or relative to quantum field theory (explained later), can extend through the barrier and we can calculate the probability of the wavefunction to extend through the barrier as a whole.

Now some of you may think that with this theory we can teleport through walls. Add a pinch of salt to this opinion, but coming from a 14 year old middleschool student, I would agree that it is indeed very much possible. Yet for one the odds are incomprehensibly low for a completely successful occurrence of a person tunneling through a wall thats even just a nanometer thick. Another would be that even if it were so to happen, a person may just go halfway through. The maths point to it being non zero but considering that even 1 cubic nanometer contains upto 1000 atoms, the chances of each elementary particle to have the probability of tunneling is astonishingly low. Keep in mind that 1 million nanometers fit in 1 millimeter.

Now onto the second topic, this is perhaps the greatest candidate to explaining how the big bang could have originated from nothing. As for virtual particles, they literally appear out of nothing, destroy each other into nothing and last for extremely low periods of time.

Yet we have detected such particles. Additionally, they form in pairs, and tend to go away from each other before colliding and destroying each other. Now if a pair of virtual

particles spawned next to the event horizon and one of these falls into the black hole, the other particle can never be destroyed. Yet to continue to exist it must borrow energy from the singularity of the black hole effectivley shrinking it. This is referred to as hawking radiation and thus causes the death of black holws, however after a tremendously long time; upto 10 times the age of the universe for the smallest black holes atleast.

Now that we have understood these 2 basic concepts, let us move into another concept related to particles. If you felt that this book seems extremely simple, there is a formula sheet given in the back for all relevant formulas if you feel interested, with explanations of variables.

Chapter 6: Quantum entanglement

Onto the last relatively easy concept of quantum physics, which is quantum entanglement. This is a rather interesting concept and one of which now triggers a variety of interpretations and theories.

In the subatomic and quantum world, elementary particles, such as electrons, have 3 properties. Mass, charge and one that most of you may be unfamiliar with, spin, which simply is

the angular momentum of the particle. Before continuing, let us clear up that protons and neutrons are not elementary particles as they can be divided into 3 smaller particles knows as quarks with both protons and neutrons being made of quarks with different spins.

Since we are going to dive into more complicated subjects, let us now explore concepts in more complicated mannars. The spin of a particle will always be up or down. However, in some instances it appears in between. Therefore to identify the probability of the real spin of the particle we use this formula

When $(0<\theta<180)$ (Spin up)
$P(S)=\cos^2(\theta/2)$

When $(\theta>180)$ (Spin down)
$P(S)=\sin^2(\theta/2)$

Where S represents spin, θ measures angme measured and P(S) is the probability of the spin being up or down.
Now, 2 particles can be stated as entangled if their spins are opposite to each other and always remain that way.

Particles are said to be entangled in terms of

quantum physics if their spins are opposite to each other no matter the distance and change states of their spins instantaneously due to their entanglement. However this can apply for almost any other property, its just that spin is the easies to understand and detect.

To put this into a simple analogy, imagine 2 boxes with 2 different objects in it. If we open any of the boxes, we can for certainly say what the other box will contain. Or imagine 2 finalist in a competiton. When the results are announced, if we know the result of one of the competitors, we will immediately know the result of the other.

Now, this would mean that no matter the distance, the state of the particle spins if quantamly entangled will change respectively faster than the speed of light.

Well you would be right, if there was information actually travelling. There is no transmission of information in the form of matter whatsoever between the particles instantly, its just the nature of the objects to react instantaneously. This oversimplification is prone to heavy arguments and this popular interpretation is still debatable, but this is the best we have as of

when I am writing this.

Quantum entangtlement thus possesses numerous possibilities for ouyr species. For one, we can make batteries that charge instantly if we learn to manipulate this property. We can additionally change the state of matter as well, a form of telekenisis if you may say in real life. That is if we can produce matter made of quantum entangled particles, learn to manipulate it and make sure that it can eb usable without leading to a huge catastrophe. Yet we are an extremley long way from telekenisis, let along instantaneous batteries.

Chapter 7: Standard model of the Universe

The standard model of the universe is perhaps the most successful model in our current study of the universe. In fact, it is just 1 step away from being the first theory of everything; a model of the universe that describes everything and how it works.

The standard model consists of 17 fundamental particles with variations to some of these particles. These are also referred to as elementary particles as within this model, can not be divided any further. There are 2 main

classifications, fermions and bosons. In short, fermions are the particles that help define matter including protons and neutrons and bosons are particles that help define other forces within the universe. Additionally, fermions have half integer spin values whilst bosons have whole integer values for spin.

The fermions can be divided even more into 2 other sets, quarks and leptons. The main difference is that quarks can be influenced and do interact with the strong force (the force that attracts and repels quarks towards each other). within the universe whilst leptons do not, yet still react to electromagnetic and the weak forces (force responsible for the weakened attraction of electrons to nuclei in atoms.)

Finally, within fermions, there exist another overlapping set called generations of which there are 3. These are respectively the first, second and third generation of sets, in which the mass increases as you ascend in generation.

The main fermions you should be familiar with are the quarks, having a up and down spin. These quarks under the influence of the strong force combine together to form protons and neutrons. Additionally electrons as well, as these

3 elementary particles along with the neutrionos for electrons are all within the first generation and make up almost all of the matter in the universe.

There are quite many other fermions such as charm and strange quarks, meuons and meuon neutrinos in the second generation and top and bottom quarks along with tau and tau neutrinos in the 3rd generation, of which this generation being the heaviest, but also extremely rare in the universe.

One more thing to know about all fermions is that they have another alternative form, where the elementary particles have the same properties but opposite charges.

Now when it comes to bosons, the photon is perhaps the only one you all must be familiar with. This is the particle in light that provides it with its electromagnetic properties and characteristics. Gluons are the particles that dictate the strong force in the universe. W^+ , W^- , and Z^0 are the particles that help definie the weak force in our universe. And finally, there exist the higgs boson or H^0. This boson creates a field for the particles that when interacted with, gives them their mass accordingly. This should not be mixed up

with gravity, as that is a completely different particle altogether.

Now this standard model of the universe is accurate upto 0.000000000002% after significant amounts of testing. Additionally it has helped combine vague understandings into one model that helped merge the thousands of perspectives and understandings beforehand inso such a simple formula. It has even contributed to significant advancements in science, both theoretical and practical uses such as hadron therapy and maglev trains. The only problem is that you might have noticed there is no particle for gravity.

Now this theoretical particle called the gravitron when included breaks down the fabric and accuracy of the model. And this problem leaves a lot of unanswered questions and limits the validity of the standard model of the universe as a theory of everything.

Chapter 8: Many worlds interpretations and quantum immortality

This is a extension to the Schrodigners cat thought experiment however this is one that is more open to abstract thoughts than formulas and calculations.

The interpretation goes like this. For every outcome, there is a universe that is created or exists with that outcome. In simplier words, if I flip a coin, the fabric of reality will create atleast 2 universes where both outcomes are recorded for it.

Now this can seem simple enough if you narrow your perspective. There is a universe where D-Day had failed or a universe where Iphones have not been invented yet. However, when we try to apply that into the quantum world of possibilties, every passing second, an incomprehensible number of universes are created if we believe in the many worlds interpretation.

To put this into perspective estimates of the size of our observable universe, which is the visible range of the universe present to us due to the rapid expansion of spacetme, stretches up to 46 billion light years in radius or upto 40 followed by 80 0’s, in cubic meters in volume. In a area of 1 nanometer cubed, there are itself millions of atoms and billions of elementary particles.

Considering that even the smallest events for 1 of these particles that could cause it to end up at any posistition leads to an infinite number of universes as there are an infinite number of

states the particle could go to if it decides to change its posistition by even less than the plank length. Just imagine how many possible outcomes would be there for 100 or even a million of these particles which are all within a space less than the thickness of your hair.

Now onto the concept of quantum immortality imagine this scenario. You get into a car crash and there is a 0.1% chance of you dying. According to the many worlds interpertation, no matter what, there will be 1 universe in 1000 created in which you live. Now until such an event across the trillions of timelines arises where your chance of death are absolutley 0 and not even by the slightest bit more or less, there is a universe where you would have lived for an incomprehensible amount of time and will for the foreseeable futute.

Now with quantam immortality out of the way, there can arise millions of paradoxes due to the certainty of absurd possibilities occurring. Before delving into clunkier formulas, take a moment to think of the wildest possibilities that can occur with the many worlds interpretation. For any outcome with a non 0 probability no matter the odds, it has and will have happened. There is a universe for instance you were a

ruthless dictator or a universe where you became the fictional hero that you read about in comic books.

Chapter 9: General relativity and Special relativity

This is not directly involved in quantum mechanics, but outside of it, is the best way of describing gravity as we know it. Additionally, whoever is able to integrate (not in literal calculus terms) the standard model with general relativity or with gravity will be remembered forever in the field of science and of mankind alike as the founder of the “theory of everything.

This will be a short chapter, but one worth noting. To visualize this, imagine a trampoline or any 2d fabric strengthened out to form an elastic plane. When we place an object on that plane, the straight and rigid fabric tends to warp and curve in accordance to the mass and distribution of the object. Now according to general relativity, this object has a mass, thus having a gravitational force of influence. This influence will act upon the fabric, which in the analogy represents the warping of space time.

Space time as a whole won’t be just a 2d plane, but a 3d grid, with a posistition in time, thus

having 4 dimensions, 3 spacial and 1 relative to time.

Now general relativity has been extremnley useful in explaining various phenomena in our universe and has opened the door to many possibilities such as einstein rosen bridges and black holes, many of which have been proven. However, it has one flaw in which it’s inherit inability to work with the standard model of particles has basically rendered both theories with loads of vague spots that prevent a solid theory of everything of existing.

Onto special relativity the iconic formula E=MC^2, sums up the basis of special relativity. In short, it suggest that the energy of a body is due to the mass multiplied by the speed of light squared. This simple formula outlying the relationshp between such properties has lead to various other findings such as the effect of time dilation, where time is experienced slower for those travelling at high speeds or near objects with significant gravitational pulls due to the warping of spacetime relative to their posistition.

These 2 theories of relativity laid out by Einstine may be taken for granted today, but these are

perhaps the fundamentals in how we as humans today try to understand the workings of our universe as a whole.

Chapter 10: String theory

In this book I will be covering 2 possibile theories of everything, one most of you have heard already and the other not as much yet just as intriguing. However both are not confirmed to be the true nature of the universe, scientist and scholars still find it useful to model our understandings in those lenses. It’s like 2 analogies for the same message, both may provide different perspectives but intend to convey the same total message.

Starting with the former, string theory has been studied for decades and has been recognized by many high level scientist as the best candidate for the theory of everything.

In extremely simple words, it suggests all of the elementary particles in the standard model are to be composed or even be in the form 1 dimensional strings. These strings have a vibration and like in a guitar where every string and vibration makes a different sound, the strings in string theory make up different

properties of the particles.

Now this sounds extremely simple but also holds room for a significant amount of process, Once suggested in 1969, it quickly graduated to becoming the best candidate for the theory of everything. The concept is extremely simple, but makes complete sense from both a naive and expert’s perspective. What better way to determine the nature of such particles than assume it consist of something whose behaviour determines it, in which many properties such as the speed and type of vibration can determine the properties or type of particle.
However, string theory has one problem, which is it’s intricacy. Its initial variant, bosonic string theory needed 26 dimensions to properly function, most of which exist below the distance of the blank length ($1.6x10^{-35}$ m). The best candidate whilst having the second least amount ofo dimensions (and a lot of variants) has 11 dimensions, also known as supersting theory.

Additionally, it is extremely hard to validate this, even more so with it having 11 dimensions. These dimensions exist in such small scales so not only are they hard to measure, but also to even detect and calculate in real time.

Still, the ability for it to atleast combine almost if not all in some forms of string theory, aspects of general relativity and the standard model has provided ample validity as in many peoples eyes, the best candidate for a theory of everything. All one has to do is simplify it into 4 dimensions, yet that in itself is a lot harder than just removing variables in a matrix expression.

String theory is perhaps widley accepted as the best candidate for a theory of everything. But until we can experimentally prove it, it just remains as the best way of describing such particles wihtoug substantial proof.

Chapter 11: Loop quantum gravity

This is perhaps the second most popular theory, a sort of expansion on general relativity however, yet one with quite a few more flaws. However, this is not one to just leave it as it’s overshadowed by string theory as the benefits of trying to frame the universe in this lens can give us significant perspectives on the universe that are impossible in other models.

It suggest that spacetime is more like a sweater instead of a fully smooth surface. From afar it may appear matte and flawless but when we

zoom in, it has intricate details and texture. This level of detail however in the sweater is only visible below the plank length in loop quantum gravity's interpretation of spacetime. And it does present itself with various advantages.

For one, it removes the possibilities of tachyons (particles that move faster than light) and singularties, and does not need 11 dimensions to work in. Additionally, the ability to quantize spacetime and the implementation of hamiltonian and movement constraints to help account for the definiment of the quantum field allow for tremendous room of possibilities when studying particles and the nature of the universe in this lens. However there are quite many limitations to this theory as well and the positive aspects can also be seen as negative as well.

For one, there are loads of potential inconsistencies in calculations involving hamiltonian constraints which lead to the literal breaking of spacetime and the maths related, along with the making sure the absence of anomalies (inaccuracies in integration or other calculations) is consistent as calculations continue to advance and most of all, it's interpretation of singularties as compared to tesed evidence.

Loop quantum gravity in short may simplify the dimensions, but due to its dynamic and constantly changing fabric of spacetime requiring hamiltonian constraints and rigorous checks for anomylies lead to loads of potential inaccuracies that too cannot be tested as all 3 theories are below the plank length. This is also why most scholars tend to follow the concepts of string theory due to it's ability to include the possibilities of singulartities and tachyons, whilst integrating with the standard model of physics better than loop quantum gravity. However, on that note, it does get more points for somewhat implementing the theories of Einstines general relativity.

Chapter 12: Quantam field theory

Before devlving any deeper, we will finally finish off the interpretations of the universe with quantum field theory or QFT for short. This is a sort of extension towards the standard model and expands coupons the first quantum theory by schrodigner that will be detailed in this section.

Before going on to the "second" quantization, let us look into what is the first quantum field

theory. This was proposed by Schrodigner and the popular schrodigner equation, part of the “first” quantization, is used to calculate the evolution or change of a particle, by treating it as changes in a wave. It uses wave functions, (ψ) prounsed psi, along with calculating the corresponding total energy using the method of the Hamiltonian operator, (H), to calculate this evolution of the movement of a particle or a wave function using the formula (H ^ ψ = E ψ) if not considering the dimension of time and (iℏ d⁄d(t) ψ(t)=H ψ(t), where we include the vector state in ψ(t), along with the derivative of time as well.

Now if you did not understand the whole top paragraph, it’s fine, you don’t need to. What you do need to know is that this is extremely ineffective when it comes towards actually predicting the movement of particles in quantum physics. The main reasons include, it’s inability to be utilized along Einstines general relativity and the other being it counting ach individual particle, leads to inaccurate maths as repetitions are quite common, which leads to wrong totals and thus probabilities and other aspects along with loads of time consumed as it accounts for each particle in the field.

The “second quantization” involves the approach that instead of the particles existing, they are

simply just excitations of space in a field. Yes this is why it’s called quantum field theory. It’s because it describes the behavior of these particles as just changes in space for that particles occupied field, usually smaller than the plank length.

To visualize this, imagine a spring with a bob on top. It can move up and down. Now make it into a line. We can create harmonic motions using wave functions and make a simple osscliating pattern. Extend it into a 2D grid of those springs and we get a more rhythmitic and ossclilating pattern with loads more to account for such as directional vectors and integrations. Finally, imagine it for a 3D space. This would be extremley beautiful, but extremely complex to calculate for even the simpliest of wave functions.

However, treating particles and their behaviours as osscialtions in fields has proven to be extremely effective for upto 1 parts in a billion or 0.0000000000002% chance of redundancy. This allows scientist to accurately track the behaviour and energy of particles along with their behavour at agy given time, with the only caveat being the quite complex formula.

Yet it gets better. This theory can be expanded into explaining other branches of quantum mechanics such as quantum chromodynamics or the movement

of gluons, quantum electrodynamics, quantum flavordynamics or study of the weak force and even more, the study of the higgs field, which gives the particles their mass at such small scales, where general relativity ceases to exist or as of what we know.

However, quantum field theory possesses a significant limitation, though stated earlier in the book, does prevent us from unlocking the true nature of the universe. The Hesienberg uncertainty principle applies to this theory and if the purpose of this theory is to get to know the properties and posistition of the particle and it’s wave function, the Heisenberg uncertainty principle prevents us from knowing both the location and discrete movement of the wave function on the plane. So consider quantum field theory with a grain of salt. Additionally, there are a myriad of equations that make the process of calculating such characteristics extremely hard and each formula has it’s own redunciencies and perks. For example, Schrodigners equation may be able to tell the precise location but is as effective as newtonian equations due to it’s inefficient method of accounting for all particles in the given plane.

This also helps me conclude this topic by mentioning how tantalizingly close it is towards merging both the standard model and general

relativity. The only problem is that when we add gravity and it’s functions, the math begins to break down causing abnormalities and infinities that can not be renormalized.

Chapter 13: The Lagarian equation and Hamiltonian mechanics

As we approach the end of the book, I would advise readers who have not developed a fond interest of quantum mechanics so far to perhaps not read this chapter. This is perhaps the most complicated out of the sort and may take a bit of time to understand, (despite it being only 800 words).

In most physics classes, we are taught Newtonian physics and it’s formulas for calculating energy, which is the iconic F=MA. Though these formulas and concepts apply well in the real world, there were extensions made decades and centuries later, notably by Jospef Louis Lagrange and Willam Rowan Hamilton. Though these 2 minds intended to provide new perspectives for classical mechanics, their formulas work extremely well in terms of calculations in the quantum world.

We will explain these 2 concepts briefly but with great detail (as with the whole book). Lagrange’s approach started off by instead calculating the difference of kinetic and potential energy, known as

the Lagragian. Now this can be expanded with the Euler Lagrange formula. For these formulas and for the formula section below, a decent base of singlevariable calculus or more would be extremely beneficial towards this concept and the formulas shown in quantum mechanics.

However, to oversimplify the Euler Lagrange equation in the retrospect of quantum mechanics, this allows us to predict the path or trajectory of a particle by implementing the principle of least action into a partial derivative (∂) with respect to its Lagragian. The principle of least action suggests that in nature, particle will take the path that conserves the most energy or needs the least amount of work. Richard Feynmann as well expands upon this with his path integration formula where all of the possible paths help shift the probability of the most accurate path.

Now this in quantum mechanics has a plethora of implementations, especially in predicting the movement of particles and quantum fields under various circumstances. However, the most iconic of which, which is a formula that tells us almost everything about the movement of particles in the quantum world, is the extremely famous Lagragian Equation. However, it probably isnt as famous due to it’s extreme length. I have added an extremely simplified version in the formulas section of this

book but the original one that considers all of the parameters and variables is much more complicated.

Now onto Hamiltonian physics, the Hamiltonian operator as mentioned before consists of the sum of the Potential and kinetic energies. This seems fairly simple but even in classical physics, it provides such great depth to the geometric visualization of a pendulum's energy and movement through its graphical representation on “phase spaces” and the “flow” it creates, which is a concept on its own quite worth learning.

Yet the Hamiltonain operator with its extensions such as the Hamiltonian constraints in Einstein's general relativity and loop quantum gravity have profound implications in the world of quantum mechanics. From the myriad of implications, one of which that stands out is its presence in defining both Schrodigner equations, both with respect to time. It’s implication for fining the sum of the potential and kinetic energy with respect to the wavefunction has provided us with a formula that can clearly define the parameters and behavior of particles and has helped us understand significant aspects of the quantam world.

It’s implementations also help by bring classical physics directly into quantum through canonical

quantization and even in Noethres theorem, that helps link symmetries such as translational and rotational symmerty refer to the conservation of momentum and angular momentum respectively.

Overall, these 2 concepts, though intended for classical physics, have helped significantly towards our understanding of the quantum world and it’s intricate aspects. Without these, there would be no understanding of quantum mechanics if not the branch as a whole. It stands as a testimote to how pivotal these aspects and interpretations are and have allowed us to develop and learn so much more of the world in 200 years than most of human civilization beforehand.

Chapter 14: Uses of quantum mechanics in the real world

Finally, we have entered the last chapter of the book, in which we delve into the real uses of quantum mechanics and physics.

In terms of medicine, with understanding the biochemical reactions that occur in our body, scientist and doctors alike can leverage the properties of quantum mechanics to help in treatment of various disorders, diseases and illnesses, from small level cuts towards figuring out alternative cures for cancer. Additionally, medications with the leverage of quantum

mechanics can be significantly more efficient and effective when applied.

However, the main field of their use is in technologies such as transistors and semiconductors. With the help of quantum physics, we can makle quantum computers that use quantum bits with superposistition, quantum entanglement andquantam tunneling to perform higher magnitudes of computing impossible on normal levels.

This can also provide an unbreakable layer of cryptography. Using quantum key detection, once a threat is dectected, using quantam encryption, all passwords and messages will be theoretically impossible to decode considering the implementation of entanglements and superposistitons of the various q-bits.

Quantum mechanics can also be used in more day to day products or atleast day to day for future civilizations. Using quantum tunneling, we could theoretically make barriers passable for certain people or using entanglement, create telekenisness like abilities present in science fiction movies.

On a closer timeline however, we could also make more precise ways of measuring time and additionally speed up the rate at which we produce

energy with more efficient photovoltaic cells in solar panels or even other forms of producing energy, using or based off quantum mechanics; potentially even dyson spheres can be constructed and made with a fraction of expected resources. (A dyson speare is a device that absorbs significant amounts of radiated energy from the sun from outer space and directs it back to earth, giving humans enough energy for a type 2 civilization.

In my opinion, the implementation of quantum mechanics is limited to our imagination and a bit of political intervention. However, it will take a bit more understanding from our end of the quantum world and this field of science along with more public knowledge to reach such possibilities for our civilization.

Conclusion

Quantam mechanics is still filled with unknowns. And perhaps within the next 30 years, all of the knowledge that I had published as the new quantization, will be rendered uselewss as new theories and answers are found.

And that is what makes quantum mechanics exciting. Unlike other branches of science, quantum mechanics has no end. When we find one story to explain how the universe works, we find answers to old questions, but are left with even

more questions and voids to fill. We then spend upto millennials finding solutions and once found, help us unlock new layers of understanding.

Quantum mechanics can be very complicated and get extremely boring with the numbers and calculations. But in the end, the answers that it leaves us with allow for us to formulate the theory of everything or in simpler words, the knowledge that explains everything about the universe.

Formulas to note down

The schrodigner equation: $\hat{H}\Psi = E\Psi$
$\hat{H}$: Hamiltonian Operator (Sum of Kinetic and potential energy)
Ψ: Wave function for the particle
E: Energy